Investigating gender differences under time pressure in financial risk taking

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Abstract

We investigate the nature of gender differences in financial risk taking under time pressure. Motivated by the large gender imbalance on financial trading floor we investigate gender differences under pressure and whether testosterone plays a role in gender differences in risk attitude under pressure. We find that testosterone exposure affects both outcome and probability sensitivity in men. We also find that testosterone exposure makes men relatively more risk seeking and optimistic when having to make risky decision under time pressure.
1 Introduction

Why are there so few women trading in the markets? The last fifty years have seen more and more women participating in the labour market. In many professions the percentage of women approaches or exceeds 50%. Yet a few professions stay firmly outside of this evolution. The case of professional traders on financial trading floors is unambiguously one of them. Although women may represent more than half the workforce in financial services (Sethi et al., 2013) they are typically in marketing, compliance or HR roles (Jäkel and Moynihan, 2016). What scant data there is suggests that women are 15% of junior investment and trading roles (Clarke, 2013; Green et al., 2009; Lietz, 2012).

The causes of this gender imbalance are still not perfectly understood. While in some professions it is argued that an invisible ceiling prevents the access of women, this is unlikely to the case in finance, where the high pressure to perform pushes firms to look for the best talents at all cost. This study investigates what we believe may be a factor driving the gender imbalance on trading floors: differences between men’s and women’s risk preferences, particularly under time pressure.

Trading is a pressurised activity where stakes are high and time is short (Kocher et al., 2013; Oberlechner and Nimgade, 2005). To examine the relation between risk-taking, time pressure and gender, we use a standard risk elicitation experiment with substantial incentives, where biological markers of masculinity (prenatal exposure to testosterone) are measured for men and women and where choices are observed under different degrees of time pressure.

This paper contributes to three distinct bodies of research: the literature on stability of preferences; the literature on gender differences in risk attitudes and the literature on gender differences in financial behaviour and careers.

The stability of preferences has been a shibboleth of much economic theory since Stigler and Becker’s seminal paper (Stigler and Becker, 1977). Recent research, however,
has shown that preferences are not as stable as hitherto supposed. Both explicit factors, for example time pressure (Kocher et al., 2013), and implicit ones, such as levels of the hormone cortisol (Kandasamy et al., 2014), mean that people make different choices. The impact of time pressure has been largely ignored by economics (De Paola and Gioia, 2016; Kocher and Sutter, 2006) and, what work there has been, does not clearly delineate the influence of time pressure on decision making. Work rooted in experimental psychology examines the speed vs. accuracy trade-off. Speedy decisions are thought to be of poorer quality, as time pressure prevents effective information processing. This, in turn, leads individuals to fall back on heuristics rather than the information presented (see Kocher and Sutter (2006)). Where risk appetite is evaluated, most research suggests that risk taking increases with time pressure (Hu et al., 2015; Huber and Kunz, 2007; Kocher et al., 2013; Young et al., 2012). Zur and Breznitz (1981), however, find the opposite effect, although this is thought to be due to the payoff structure used (Busemeyer, 1993). Kocher et al. (2013)’s paper offer an alternative explanation for Zur and Breznitz (1981)’s results, suggesting that framing is important. Their findings show that risk appetite is stable under time pressure in the gain frame but shifts from risk seeking to risk aversion in the loss frame. Only Young et al. (2012) examined gender differences, but found none.

Alongside the literature on preference stability, this paper contributes to the substantial literature on gender differences in risk attitudes. One of the most common and consistent findings in the risk preference literature is that men are more risk prone than women (Powell and Ansic, 1997; Byrnes et al., 1999; Eckel and Grossman, 2002; Croson and Gneezy, 2009). Croson and Gneezy (2009) discussed some explanations of the gender difference in risk taking: emotions, overconfidence and risk as challenge or treats. The search for the roots of such gender differences has pointed to the role played by the androgen hormone testosterone. Testosterone (T) plays an important role in developing men’s reproductive ability and modulating men’s behaviours even more. Testosterone has been found positively associated with a number of behaviours in adult men, includ-
ing aggression (Archer, 2006), sensation seeking (Roberti, 2004), hostility (Hartgens and Kuipers, 2004), mate-seeking (Roney et al., 2003) and dominance (Mazur and Booth, 1998). Research in economics has shown that marker of pre-natal exposure to testosterone has an impact on risk attitude (Garbarino et al., 2011). We complement this research by investigating the how prenatal testosterone exposure affects risk attitude decomposed into outcome sensitivity and probability sensitivity (in an RDU model).

This paper also contributes to the literature on gender differences in financial behaviour. Coates et al. (2010) propose a hypothesis suggesting that the irrational exuberance observed during market bubbles and pessimism during crashes are mediated by the hormone testosterone. He conjectures that men and women traders are likely to behave differently with men traders behaviour driving market instability. Market experiments seem to point to such gender differences. Fellner and Maciejovsky (2007) find that women submit fewer offers and engage in fewer trades than men. Eckel and Füllbrunn (2013) show all-male markets yield significant price bubbles while all-female markets produce prices that are below fundamental value. Deaves et al. (2010) discover no gender effect in trading but observe that women trade less than men. In the present paper we compare men and women financial risk taking under different degree of time pressure. Time pressure is a key aspect of financial decisions on trading floor and we suspect that gender differences under time pressure may be one of the factors driving the gender imbalance observed in these environments. Traders make decisions in financial markets within seconds after new information becomes available (Busse and Green, 2002). Kocher et al. (2013) find that risk aversion for gains is robust under time pressure whereas risk seeking for losses turns into risk aversion under time pressure. For mixed prospects, subjects become more loss averse and more gain seeking under time pressure. Nursimulu and Bossaerts (2014) discover that the time-varying sensitivities translate into decreased risk aversion and increased probability distortions for gains under extreme time pressure. However, little is known about the gender difference in risk
attitudes under time pressure.

Overall, we find that, in line with previous research, male participants are overall less risk averse. In addition, we identify three patterns which shed a new light on gender differences in risk attitudes. First, under time pressure, both genders make riskier choices, with decisions under time pressure giving greater weight to extreme payoffs. Second, we find that male participants with more testosterone exposure make riskier decisions. Third, we find that testosterone exposure is associated with more risk-seeking and more optimistic decisions under time pressure for male participants.

These findings contribute to the literature in a number of different ways. The impact of time pressure on risk taking suggests that preferences are not stable, which has significant import for classical economic models. The impact of prenatal testosterone exposure on decision making offers an explanation for differences in risk preferences between individuals. The combined effects of time pressure, gender and pre-natal testosterone exposure on risk appetite suggests that preference stability is a complex interaction of both endogenous and exogenous factors.

Financial markets’ focus on moneymaking values competition, risk-taking and high pressure (Barbulescu and Bidwell, 2013). Descriptions of markets emphasise the role of dominance and aggression (Roth, 2004a,b). Our findings suggest that the bullish confidence to take risks, which appears to be valued within finance, more closely matches behaviours displayed by men. These results may help us understand the persistent large gender imbalance on trading floors while at the same time raising questions about its effect of financial market dynamics.

The remainder of this paper is organized as follows. Section 2 describes the design of our experiment. Section 3 introduces our structural models and estimated models. Section 4 presents our results. We conclude and discuss our results in Section 5.
2 Motivation and hypotheses

Although the idea that preferences are stable is widely accepted, this was not always the case. Keynes observed that “there is the instability due to the characteristic of human nature that a large proportion of our positive activities depend on spontaneous optimism rather than mathematical expectations, whether moral or hedonistic or economic” (Keynes, 1936). Over the last decade, a great deal of progress has been made on studying these ‘animal spirits’ and their impact on investors and financial markets.

One way of distilling these animal spirits is to examine time scale over which they act. Short term factors range from seconds to hours and include time pressure, transient elevations of hormones or neurotransmitters, and fluctuations in blood glucose levels. Medium term factors are from hours to weeks, for example chronic elevation of hormone levels, which fundamentally alter the architecture of cells. Long term factors, from months to years, could include market composition i.e. the types of people participating in the market. Each of these categories has been examined and the view emerging from this research and from behavioural finance is that, in contrast with the standard assumption of the theoretical finance and the efficient market hypothesis in particular, market participants’ risk attitude may vary over time. This leads them to sometimes make choices which can seem downright irrational.

Short term factors have recently produced an outpouring of research. The impact of time pressure on decision making has already been discussed but recent work on steroid hormones has also demonstrated that preferences are not stable. Circulating testosterone levels, for example, appear to foster greater risk appetite in bull markets (Coates and Page, 2016). Coates and Herbert (2008) show that male traders with elevated testosterone have higher returns. Apicella et al. (2008) find a positive relationship between testosterone and risk taking in an experimental task on male undergraduates. However, these two studies do not include female subjects. Sapienza et al. (2009) find on MBA
students, men have significantly higher levels of salivary testosterone than women, but a positive correlation between circulating testosterone and risk taking for women, not for men. Stanton et al. (2011) show that male and female students with higher levels of salivary testosterone make riskier choices than those with lower levels; the effect was similar for men and women, but more pronounced for women. Schipper (2012) find testosterone is negatively correlated with risk aversion in males for gains only. Cueva and colleagues found that testosterone shifted people towards riskier assets by inducing increased optimism about future price changes (Cueva and Rustichini, 2015). The role of blood glucose in shifting preferences has also been extensively studied. In a book capturing much of the extant research, Baumeister shows that glucose depletion tends to lead to individuals taking less risk (Baumeister and Tierney, 2011). Short term factors, therefore, can radically alter risk preferences.

Medium term factors can have a similarly profound effects. Kandasamy et al. (2014) evaluated the impact of both acute and chronic cortisol administration on risk taking. Cortisol is a hormone produced in response to a wide variety of stresses (Selye et al., 1936). Acute cortisol administration (one dose) appeared to have little effect on risk preferences in the Hey and Orme (1994) lottery task. Chronic cortisol elevation, where participants had their cortisol levels raised 69% above baseline to mimic the stress response observed in financial markets (Coates and Herbert, 2008), reduced risk taking by 44%. There was also a gender difference where men were more sensitive to small probability events and less sensitive to large probability events than women. Chronic testosterone elevation has also been speculated on as a possible medium term factor (Coates et al., 2010). Studies in other species have shown that success in competition elevates testosterone levels and that this can, in turn, increase the likelihood of further success. This positive feedback loop, the ‘Winner Effect’ (Wingfield et al., 1990), can produce medium term (hours to weeks) shifts in risk preferences.

Long-term factors, running from months to years, can shift preferences directly but
also through interaction with shorter-term factors. One good example of a long term factor is \textit{in-utero} testosterone exposure. The default pattern for developing embryos is female. The Y chromosome contains the \textit{SRY} gene which transforms the indifferent gonad into male testes. These testes then produce testicular hormones (e.g. testosterone) which confers the male primary and secondary sex characteristics. Between 12 and 18 weeks of gestation male fetal plasma testosterone levels reach nine times that of females causing the formation of male external genitalia and conformational alterations in the brain and spinal cord (Breedlove and Hampson, 2002). This testosterone peak also affects the length of the digits. Intra-uterine testosterone levels negatively correlate with the ratio between the second and fourth digits (index and ring fingers, known as 2D:4D ratio) (Lutchmaya et al., 2004). Higher concentrations of foetal testosterone produce a lower 2D:4D ratios and men typically have lower 2D:4D ratios than women (Manning et al., 1998; McIntyre, 2006).

A second androgen peak is seen in the three months after birth, related to an LH surge, but the function of this remains unclear (Swerdlow et al., 2002). A third androgen peak during puberty results in the development of male secondary sex characteristics and increased muscle bulk, and again has further effects on cerebral architecture. Again, this pubertal peak affects bodily conformation, notably in the ratio between facial width and height, or fWHR (Verdonck et al., 1999; Weston et al., 2007), with males having larger ratios than females.

These markers of testosterone exposure can be readily measured and impact on risk taking and decision making. Coates et al. (2009) find that male traders with lower 2D:4D have higher profitability and Coates and Page (2009) find that this result is entirely driven by greater risk taking. Garbarino et al. (2011) design a financially motivated decision-making experiment and discover that: men have lower 2D:4D than women and the difference is significant; women make more risk averse choices compared with men; both men and women with smaller digit ratios make riskier financial choices and the
effect is identical for men and women. However, no significant correlation between the 2D:4D and risk preferences are observed by Schipper (2012). Drichoutis and Nayga (2015) found no effect of digit ratio on either risk or time preferences. Little is known about the associations with fWHR. The differential impact of testosterone exposure on risk preferences for both genders is still inconclusive.

The 2D:4D ratio has been shown, in men, to be negatively correlated with good visual and spatial performance (Manning and Taylor, 2001; Kempel et al., 2005), dominance and masculinity (Fink et al., 2007), and sensation seeking (Fink et al., 2006). Tester and Campbell (2007) find that the significant relationship between the 2D:4D ratio and sporting achievement was nearly identical in both men and women. However, several traits were only discovered in women, for instance, sensation seeking, psychoticism, neuroticism (Austin et al., 2002), verbal fluency (Manning, 2002) and social cognition (Williams et al., 2003). The predictions of face width-to-height ratio are mostly found in men. Carré and McCormick (2008) discover that male undergraduate students have a larger facial width-to-height ratio, higher scores of trait dominance, and more reactively aggressively compared with female students. However, the individual differences in fWHR predict reactive aggression in men, not in women. Valentine et al. (2014) support the idea that fWHR is a physical marker of dominance and men with higher ratio are more attractive to women. Lefevre et al. (2014) suggest links between fWHR and self-reported aggression in both men and women, as well as dominance in men, but still not in women.

As this study examines the instability of preferences and the relation between gender and risk taking, we can combine elements of the different time categories. So we can look at long-term factors, such as pre-natal testosterone exposure, in combination with more short term factors, such as time pressure. In the light of this we can propose the following hypotheses:

Hypothesis 1 (Time pressure) Time pressure can increase an appetite for risk.
Hypothesis 2 (Gender) There is an overall gender difference on risk preferences with men being more risk seeking.

Hypothesis 3 (Testosterone) More testosterone exposure can be associated with more risk seeking attitudes.

Hypothesis 4 (Gender × Time pressure) There is a gender difference under time pressure with men becoming more risk seeking relative to women.

Hypothesis 5 (Gender × Time pressure × Testosterone) The gender difference in risk attitude under time pressure is influenced by testosterone exposure.

3 Method

3.1 Experimental Design

The experiment was conducted at the Queensland Behavioural Economics laboratory at QUT. Undergraduate students (N=154) were recruited to take part in the experiment. Upon entry in the room of the experiment, participants were randomly assigned to a computer terminal. To measure markers of testosterone exposure, photographs of the subject’s face were taken and the right hands of the participants were scanned (see Fig. 2). Then the facial width was measured by the distance between the left and the right zygion (bizygomatic width) and the facial height was measured by the distance between the upper lip and brow (upper facial height) based on the photographs (Carré and McCormick, 2008). The lengths of the second and fourth digits were measured from the basal crease (i.e., the crease closest to the base of the finger) to the central point of the finger tip (Garbarino et al., 2011).

Participants then engaged in a standard risk preference elicitation task, the Hey and Orme (1994) Random Lottery Pair design. This task consisted in 90 decisions situations between pairs of lotteries. Participants were presented with a pair of pie
charts describing the probabilities of four fixed monetary prized of $0, $15, $30 and $45. A sample of lottery pair is shown in Fig. 1 below. For instance, Lottery A offered $0 payoff with probability 0.25, $15 with probability 0.375 and $45 with probability 0.375, whilst Lottery B offered $15 payoff with probability 0.875 and $45 with probability 0.125. The expected payoff for Lottery A was $22.5 for Lottery B $18.75. However, there were no numerical references to the probabilities and expected payoffs displayed, participants had to judge from the pie chart. At the end of the experiment, one lottery pairs which the participant selected was randomly chosen for payment, thus linking participant decisions to the outcome they receive.

To investigate the role of time pressure on risk preferences, the experiment was split in three sessions with different time constraints. One session had no time constraint, another one required decisions to be made within 8 seconds (moderate time constraints) and third session required decisions to be made within 4 seconds (tight time constraint). Given that each decision involved comparing two pie charts with different pie sizes for up to 4 outcomes each, the 4s constraint seemed to create substantial time pressure. Each session had 30 pairs and the order of three sessions were randomly assigned to each subject. Participants were asked to complete the tasks individually and independently on a computer. The experiment was programmed in z-Tree (Fischbacher, 2007).

Table 1 presents summary statistics about the sample of participants. We find that
on average males have lower 2D:4D than females and have lower fWHR in our sample. However, the differences are insignificant.

Table 1: Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>fWHR</th>
<th>2D:4D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>t</td>
<td>p</td>
</tr>
<tr>
<td>All Participants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>80</td>
<td>1.842</td>
<td>0.963</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.140)</td>
<td>(0.032)</td>
</tr>
<tr>
<td>Female</td>
<td>74</td>
<td>1.875</td>
<td>0.967</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.108)</td>
<td>(0.042)</td>
</tr>
<tr>
<td>Total</td>
<td>154</td>
<td>1.858</td>
<td>0.965</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.126)</td>
<td>(0.037)</td>
</tr>
<tr>
<td>Caucasians</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>50</td>
<td>1.836</td>
<td>0.962</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.141)</td>
<td>(0.034)</td>
</tr>
<tr>
<td>Female</td>
<td>35</td>
<td>1.873</td>
<td>0.960</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.106)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>1.851</td>
<td>0.961</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.128)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>Non-Caucasians</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>30</td>
<td>1.852</td>
<td>0.965</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.142)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>Female</td>
<td>39</td>
<td>1.877</td>
<td>0.973</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.111)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>Total</td>
<td>69</td>
<td>1.866</td>
<td>0.970</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.125)</td>
<td>(0.040)</td>
</tr>
</tbody>
</table>

Note: Standard deviations are in the parenthesis

3.2 Estimation Procedure

To study risk preferences, we fit a rank dependent utility model (RDU). This model which contains expected utility (EU) as a specific case allows us to disentangle risk attitudes between a sensitivity to payoffs via the curvature of a utility function on outcomes (like in EU) and a sensitivity to probabilities via the curvature of a probability weighting function (Wakker, 2010). We estimate the models parameters by maximum likelihood method, assuming a random utility model whereby participants choose the lottery with the highest utility plus an element of random noise, which can be considered
as a cognitive error. The utility of each lottery is determined by the function:

\[ V = \sum_{k=1}^{K} w_k \times U_k \]  

(1)

where

\[
\begin{align*}
\begin{cases}
  w_i = \omega(p_i + \cdots + p_n) - \omega(p_{i+1} + \cdots + p_n) & \text{for } i = 1, \ldots, n-1 \\
  w_i = \omega(p_i) & \text{for } i = n
\end{cases}
\]

In the equations above, \( k = 1, \ldots, K \) and \( K \) is the number of possible payoffs in a lottery. The subscript of \( w_i \) indicates payoffs ranked from worst to best. In addition, the probability weighting function \( \omega(p) \) is applied to the aggregated probabilities, so the decision weights \( w_i \) are derived by the differences in these transformed aggregated probabilities.

For the utility function on outcomes we use the standard power Constant Relative Risk Aversion (CRRA) utility function:

\[ U(x) = \frac{x^{1-\alpha}}{1-\alpha} \]  

(2)

where \( x \) is the payoff of each lottery. \( \alpha (\neq 1) \) is the coefficient of our power CRRA and the parameter to be estimated. If: \( \alpha > 0 \), it corresponds to risk aversion; \( \alpha = 0 \), risk neutral; \( \alpha < 0 \), risk loving.

As per the probability weighting function. We use the two parameter weighting function proposed by Lattimore et al. (1992):

\[ \omega(p) = \frac{\delta p^\gamma}{\delta p^\gamma + (1-p)^\gamma} \]  

(3)

and \( \gamma, \delta > 0 \). The parameter \( \gamma \) determines the curvature (concavity or convexity) of the weighting function. If: \( \gamma > 1 \), this gives the probability weighting function an “S-shape”
such the small probabilities are underweighted; \( \gamma < 1 \), this gives an “inverse S-shape” such that small probabilities are overweighted. Note that the rank-dependent model means that small probabilities reflect the extreme outcome, so the value of \( \gamma \) determines whether small probability will be under- or overweighted.

The parameter \( \delta \) provides an additional weight on the payoff probability. If: \( \delta < 1 \), the probability \( p \) is downweighted, indicating a pessimistic view of the outcome; \( \delta > 1 \), the probability is overweighted, indicating an optimistic view. Further, if \( \gamma = \delta = 1 \), the model would be reduced to Expected Utility Theory (EUT), and for all values of \( \gamma \) and \( \delta \), \( \omega(0) = 0 \) and \( \omega(1) = 1 \).

For the estimation of the random utility model, we follow Wilcox (2008)’s suggestion to make the error term variance depend on the magnitude of the outcomes being considered in the decision situation. The difference in utility between two outcomes is therefore modelled as:

\[
\nabla V = \frac{\lambda(V_A - V_B)}{U(z_{\text{max}}) - U(z_{\text{min}})}
\]

where \( \lambda \) represents the overall scale of the error term and \( U(z_{\text{max}}) - U(z_{\text{min}}) \) the influence of the specific context of the decision on the scale of the error term. The subscript of “A” and “B” represent two lotteries in each pair and the \( z_{\text{max}} \) and \( z_{\text{min}} \) denote minimum and maximum possible outcomes in each pair.

The likelihood function of observed responses from participants depends on the estimates of core parameters \( \alpha \), \( \gamma \) and \( \delta \):

\[
\ln L(\alpha, \gamma, \delta; y) = \sum_m \left( (\ln \Phi(\nabla V)|y_m = 1) + (\ln (1 - \Phi(\nabla V))|y_m = 0) \right)
\]

where \( y_m = 1(0) \) denotes the choice of lottery “A” (“B”) in pair \( m \).

We investigate the effect of the fWHR, the 2D:4D ratio and time pressure on the different parameters reflecting risk preferences. The two ratios are standardized separately.
before entering the estimation process. For simplicity of explanation, the 2D:4D ratio is reversed (indicated by the addition of the ‘R’ to the ratio, hence R2D:4D) so that higher values to indicate higher level of testosterone exposure, as they do for fWHR. To represent differences between high and low exposure participants graphically, we create a high ratio category (one standard deviation above the mean) and a low ratio one (one standard deviation below the mean). Then we introduce three variables to estimate the core parameters: “Male” as gender dummy, our testosterone markers, R2D:4D and fWHR, and categorical time sessions, “w/o”, “8s” and “4s”.

We write the model’s parameter as linear function of these different variables of interest and test for the significance of their effect on the parameters. In the section below we present the results for the RDU model, our preferred model and for the EU model which we use as a benchmark given its classical use in economics.

4 Results

4.1 Descriptive statistics

Table 2 presents summary statistics of the chosen lotteries. Female participants tend to prefer lotteries with significantly lower variance than those chosen by male participants ($t = -0.3631, p < 0.001$). Looking at fWHR and R2D:4D ratio, we observe that males in the high ratio categories (i.e. high fWHR and R2D:4D) make different choices to those in the low category. Male participants with lower fWHR and R2D:4D have lower variance of returns (fWHR: $t = -6.828, p < 0.001$; R2D:4D: $t = -4.134, p < 0.001$), suggesting that lower exposure to testosterone may be associated with less appetite for risk. Contrary to males, female participants with higher fWHR prefer lotteries with lower variance ($t = -1.967, p = 0.0494$), while no such difference is observed for R2D:4D ($t = 0.634, p = 0.527$).
Table 2: Summary Statistics of Chosen Lotteries

<table>
<thead>
<tr>
<th>Sub-samples</th>
<th>Expected Returns of Chosen Lotteries</th>
<th>Variance of Chosen Lotteries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Participants</td>
<td>22.581 (7.455) t = -0.012</td>
<td>141.899 (120.677) t = -3.631</td>
</tr>
<tr>
<td>Male</td>
<td>22.579 (7.498) p = 0.991</td>
<td>134.125 (115.201) p &lt; 0.001</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fWHR Male High Ratios</td>
<td>21.939 (7.613) t = 2.102</td>
<td>153.187 (126.906) t = -6.828</td>
</tr>
<tr>
<td>Low Ratios</td>
<td>22.598 (7.319) p = 0.036</td>
<td>119.755 (106.400) p &lt; 0.001</td>
</tr>
<tr>
<td>Female High Ratios</td>
<td>22.701 (7.495) t = -0.4458</td>
<td>127.069 (111.441) t = -1.967</td>
</tr>
<tr>
<td>Low Ratios</td>
<td>22.530 (7.508) p = 0.656</td>
<td>116.523 (99.388) p = 0.0494</td>
</tr>
<tr>
<td>R2D:4D Male High Ratios</td>
<td>22.086 (7.550) t = 0.582</td>
<td>156.388 (127.312) t = -4.134</td>
</tr>
<tr>
<td>Low Ratios</td>
<td>22.396 (7.340) p = 0.561</td>
<td>121.312 (115.164) p &lt; 0.001</td>
</tr>
<tr>
<td>Female High Ratios</td>
<td>22.704 (7.525) t = -0.525</td>
<td>116.922 (104.335) t = 0.634</td>
</tr>
<tr>
<td>Low Ratios</td>
<td>22.412 (7.570) p = 0.600</td>
<td>121.785 (103.723) p = 0.527</td>
</tr>
</tbody>
</table>

Note: Standard deviations are in the parenthesis

4.2 Estimation Results

On average, participants tend to be risk averse with a concave utility function on outcomes $U (\alpha = 0.4103, SE = 0.0173)$. They also tend to distort probabilities with an “inverse S-shape” of the probability weighting function ($\gamma = 0.6745, SE = 0.0186$) and hold an optimistic view of the outcome ($\delta = 1.1962, SE = 0.0687$), implying greater decision weights on extreme prizes within each lottery. These behavioural patterns are consistent with the findings of Harrison and Rutstrom (2008) and Bruhin et al. (2010).

Table 3 and Table 4 show the results of the estimation of EU and RDEU models. Looking at gender differences, we find that males have a lower level of risk aversion.
<table>
<thead>
<tr>
<th>Model</th>
<th>EUT</th>
<th>RDEU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) α</td>
<td>(2) α</td>
</tr>
<tr>
<td>Male</td>
<td>-0.1215** (0.0609)</td>
<td>-0.1349** (0.0570)</td>
</tr>
<tr>
<td>fWHR</td>
<td>0.0299 (0.0349)</td>
<td>-0.0467*** (0.0174)</td>
</tr>
<tr>
<td>Male &amp; fWHR</td>
<td>-0.2029** (0.0807)</td>
<td>0.0750*** (0.0273)</td>
</tr>
<tr>
<td>8s</td>
<td>-0.1454*** (0.0217)</td>
<td>-0.0657*** (0.0269)</td>
</tr>
<tr>
<td>4s</td>
<td>-0.0169 (0.0268)</td>
<td>0.0024 (0.0377)</td>
</tr>
<tr>
<td>Male &amp; 8s</td>
<td>— 0.0172 (0.0091)</td>
<td>— — —</td>
</tr>
<tr>
<td>Male &amp; 4s</td>
<td>— 0.0069 (0.0098)</td>
<td>— — —</td>
</tr>
<tr>
<td>fWHR &amp; 8s</td>
<td>— 0.0837** (0.0377)</td>
<td>— — —</td>
</tr>
<tr>
<td>fWHR &amp; 4s</td>
<td>— 0.1080*** (0.0389)</td>
<td>— — —</td>
</tr>
<tr>
<td>Male &amp; fWHR &amp; 8s</td>
<td>— -0.1575*** (0.0895)</td>
<td>— — —</td>
</tr>
<tr>
<td>Male &amp; fWHR &amp; 4s</td>
<td>— -0.1623** (0.0814)</td>
<td>— — —</td>
</tr>
<tr>
<td>Constant</td>
<td>0.4616*** (0.0362)</td>
<td>0.4803*** (0.0311)</td>
</tr>
</tbody>
</table>

Note: Standard errors are in the parenthesis; &: interaction; ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level.
Table 4: Estimation Results on Reversed 2D:4D Ratio (R2D:4D)

<table>
<thead>
<tr>
<th>Model</th>
<th>EUT</th>
<th>RDEU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) α</td>
<td>(2) α</td>
</tr>
<tr>
<td>Male</td>
<td>-0.0864*</td>
<td>-0.0962**</td>
</tr>
<tr>
<td></td>
<td>(0.0470)</td>
<td>(0.0455)</td>
</tr>
<tr>
<td>R2D:4D</td>
<td>0.0140</td>
<td>-0.0210</td>
</tr>
<tr>
<td></td>
<td>(0.0214)</td>
<td>(0.0277)</td>
</tr>
<tr>
<td>Male &amp; R2D:4D</td>
<td>-0.2618**</td>
<td>-0.1636**</td>
</tr>
<tr>
<td></td>
<td>(0.1029)</td>
<td>(0.0748)</td>
</tr>
<tr>
<td>8s</td>
<td>-0.1417***</td>
<td>-0.1674***</td>
</tr>
<tr>
<td></td>
<td>(0.0215)</td>
<td>(0.0306)</td>
</tr>
<tr>
<td>4s</td>
<td>-0.0073</td>
<td>-0.0238</td>
</tr>
<tr>
<td></td>
<td>(0.0260)</td>
<td>(0.0391)</td>
</tr>
<tr>
<td>Male &amp; 8s</td>
<td>—</td>
<td>-0.0142</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0580)</td>
</tr>
<tr>
<td>Male &amp; 4s</td>
<td>—</td>
<td>0.0082</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0640)</td>
</tr>
<tr>
<td>R2D:4D &amp; 8s</td>
<td>—</td>
<td>0.0643</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0423)</td>
</tr>
<tr>
<td>R2D:4D &amp; 4s</td>
<td>—</td>
<td>0.0575*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0337)</td>
</tr>
<tr>
<td>Male &amp; R2D:4D &amp; 8s</td>
<td>—</td>
<td>-0.2878***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.1075)</td>
</tr>
<tr>
<td>Male &amp; R2D:4D &amp; 4s</td>
<td>—</td>
<td>-0.1692</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.1234)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.4655***</td>
<td>0.4755***</td>
</tr>
<tr>
<td></td>
<td>(0.0300)</td>
<td>(0.0303)</td>
</tr>
</tbody>
</table>

Note: Standard errors are in the parenthesis; &: interaction; ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level
Models (1) and (2) in Table 3 and 4 show males having less curvature in their utility function $U$. This result supports our Hypothesis 2 and is in line with a wide range of evidence suggesting that men are more risk seeking than women.

**Result 1** *Men are more risk-seeking than women.*

We do not find gender differences in the probability weighting function. The estimated coefficients of our gender dummy variable “Male” for parameter $\gamma$ and $\delta$ are not significantly different from zero in Model (3) and (4), in Table 3 and 4.

Looking at the effect of fWHR and R2D:4D we find a profound negative effect on risk aversion of male participants (fWHR: $p = 0.012$, Model (1) in Table 3; R2D:4D: $p = 0.011$ in Table 4). The effect size is calculated and displayed in the Appendix Table 5. Figure 3 represents these differences graphically. Our finding supports hypothesis 3 and the most of previous literature. We conclude that:

**Result 2** *Men with high fWHR and R2D:4D ratios are more risk seeking. No such effect is not found in women.*

In regard to the probability weighting function, the two ratios are associated with a more pronounced inverse S-shape of the probability weighting function: the coefficient $\gamma$ is lower for men with high ratios (fWHR: $p = 0.016$, Model (4) in Table 3; R2D:4D: $p = 0.018$ in Table 4). Conversely, fWHR and R2D:4D are not significantly associated with a more pronounced inverse S-shape of the weighting function for women: $\gamma$ (fWHR: $p = 0.187$ in Table 3; R2D:4D: $p = 0.130$ in Table 4). This result indicates that men with markers of higher testosterone exposure have a greater propensity to overweight small probabilities of high gain, whereas women do not.

The probability weighting function is also characterised by its parameter $\delta$ which is associated with the elevation of the curve (i.e. optimism). We find that male participants with high ratios are more optimistic about the outcome (fWHR: $p < 0.01$ in Table 3;
R2D:4D: $p < 0.01$ in Table 4), but that no such difference is observed in women (fWHR: $p = 0.885$; R2D:4D: $p = 0.694$). Figure 4 represents the differences between men and women with high and low ratios.

**Result 3** High fWHR and R2D:4D ratios are associated with:

i. **More optimism for men.**

ii. **More overweighting of small probabilities of high gain for men.**

In line with the study of Kocher et al. (2013) we also find some effect of time pressure on risk attitude. Participants tend to make riskier decisions under 8 seconds constraint with a tendency for participants to be more risk neutral. This result does not emerge for the choices under 4 second constraints. Figure 5 represents utility and weighting functions for both genders and under low (8s) and high (4s) time pressure. The utilities of both genders have less curvature under 8 seconds time constraint (fWHR: $p < 0.01$ in
Table 3; R2D:4D: $p = 0.026$ in Table 4), whereas there are no clear differences between the sessions with 4 seconds constraint and the one without time constraint (fWHR: $p = 0.523$ in Table 3; R2D:4D: $p = 0.508$ in Table 4). Furthermore, we find that participants are less optimistic about the outcome (8s: fWHR: $p < 0.01$ in Table 3; R2D:4D: $p < 0.01$ in Table 4) and have more overweighting of the extreme outcome under time pressure (8s: fWHR: $p < 0.01$ in Table 3; R2D:4D: $p < 0.01$ in Table 4). We conclude that:

**Result 4** Under some degree of time pressure

i Both men and women are more risk seeking.

ii Both men and women probability distortion of participants increase and their optimism decrease.

We now look whether gender and groups with high and low fWHR and R2D:4D have different effect on risk attitudes under time constraints. We find that both under 8s and
4s time constraint male participants with high ratios tend to have a more risk-seeking attitude than under no time constraints (fWHR & 8s: \( p = 0.079 \), Model (2) in Table 3; fWHR & 4s: \( p = 0.046 \); R2D:4D & 8s: \( p < 0.01 \) in Table 4; R2D:4D & 4s: \( p = 0.171 \)). Conversely, female participants with high fWHR ratios make more risk averse choices (fWHR & 8s: \( p = 0.027 \); fWHR & 4s: \( p < 0.01 \); R2D:4D & 8s: \( p = 0.129 \); R2D:4D & 4s: \( p = 0.088 \)). The effects of testosterone exposure are therefore opposite for males and females under time pressure. Figure 6 shows the effect of fWHR on risk attitudes under time pressure for both genders.

**Result 5** Under time pressure, men with high fWHR ratios are more risk seeking, while women with high ratios are less.

Significant differences can also be found for the probability weighting function. Under time pressure male participants are overall less optimistic about the outcome, but
the ones with low ratios turn to be pessimistic ($\delta < 1$). The gap further increases under more substantial time pressure. Figure 7 captures the gender difference on our weighting functions. In Figure 7 (b) and (d), male participants with high ratios show more optimism about the outcome. In Figure 7 (a) and (c), the effect is opposite: females with low ratios have more overweighting and more optimistic view. However, the gap is insignificant for females.

**Result 6** Under time pressure, men with high fWHR ratios hold more optimistic view about the outcomes.

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1For the parameter calculations, please refer to Table 5 in Appendix
5 Discussion and conclusion

This study disaggregates a number of elements which contribute to the instability of preferences and offers some insights into the reasons for the overrepresentation of men in front-line finance.

Short-term factors, such as time pressure, affect risk appetite but not in a linear manner. The fact that moderate time pressure (8s) increases risk seeking in both men and women ties in with existing research (e.g. Kocher et al. (2013)). The fact that severe time pressure eliminates this effect on average is intriguing though. We know that time pressure also increases the time taken to identify optimal solutions (Kocher and Sutter, 2006). So it may be that the increase in risk seeking is offset by pressure clouding judgement and so resulting in less optimal choices. Further research should help tease out these factors.

The finding that men are less risk averse than women accords with existing research.
This research, however, offers more nuanced insights by measuring the organising effects of testosterone and using this to unpick elements of this observation.

Men with high fWHR and R2D:4D seek more risk and overweight small probabilities of high gain. They also are more optimistic about outcomes than women. When we add in time pressure they also take more risk whereas women with high fWHR and R2D:4D do the opposite, taking less risk. Time pressure also makes men more optimistic.

In layman’s terms, men, and particularly those with high fWHR and R2D:4D take more risk and are more bullish about pursuing an elusive chance of winning; even under time pressure.

These results clearly demonstrate that preferences are not stable. Time pressure affects the choices people make. Remember, that each participant is exposed to exactly the same information in each case, so there is no information difference here. Rather time pressure, interferes with information processing, producing differing results. The nature of this instability is complex, being influenced by both gender and the long term organizational effects of testosterone. As such they remind us that the useful simplification of assuming that preferences are stable, may cause us to forget the fact that preference instability is both substantial and widespread.

This instability may well affect the composition and performance of markets. The mechanics of the marketplace in front line finance is pretty straightforward: people have to obtain and hold these jobs. Here is where the results of this study start to bite. Firstly, employers have to think about the kind of person whom they wish to recruit. The characteristics that seem to be prized in the markets are the ability to take risks and perform under pressure. As Barbulescu and Bidwell (2013) point out ‘The focus on markets and moneymaking within the finance sector instils an ethos of competition, risk taking, and dealing with high pressure’ (Barbulescu and Bidwell (2013), p742).

Previous research has shown that low 2D:4D ratio associated with high testosterone exposure predicts longer survival of professional traders (Coates and Page, 2009). As a
consequence, men with low 2D:4D ratio are likely to be overrepresented in the population of traders. Our result may help make sense of this fact given that male traders with low 2D:4D ratios display a greater propensity take risks under time pressure. As we have seen in this research, we do not observe such an effect of time pressure on women. If women traders are seen as taking fewer risks than their male counterpart, particularly in response to time pressure then, in a market which values such things, they may be seen as less appropriate candidates. Moreover, if they make it past the selection phase, they may well not be retained as they do not measure up to the accepted yardstick for performance.

What is interesting is that taking less risk and making fewer trades might not be a bad thing. There is evidence, albeit from brokerage accounts rather than trading, to suggest that women earn better returns than men, and this is thought to be because they are less overconfident and trade less (Barber and Odean, 2001).

Our results suggest that a combination of preference instability and physiological conditioning may favour a preponderance of men in the market. This is, of course, difficult to prove in any definitive sense as counterfactuals are not readily available. But our findings on gender differences, the role of prenatal testosterone exposure and of time pressure suggest that women may be at a perceived disadvantage in a pressurised trading environment. This, in turn, may mean that they are less likely to be recruited and retained.

A market that is skewed to favour employing men may bring its own set of problems. Markets are well served by diversity as a means of tempering herd instincts. Some authors e.g. Coates and colleagues (Coates et al., 2010), have suggested that improving gender diversity may improve market stability. This is supported by experimental evidence which suggests that both gender (Cueva and Rustichini, 2015) and hormonal diversity (Cueva et al., 2015). So the effects of gender, preference stability and hormonal exposure may have significant repercussions.
The assumption that preferences are stable is one which has helped economic modelling but also, potentially, destabilised markets. Time, gender and hormonal exposure all contribute to preferences and the complex ways in which they vary. By teasing out the different strands of influence we can produce better models and defray the economic and social repercussions of our assumptions that preferences are stable.
References


Keynes, J. M. (1936). The general theory of interest, employment and money.


Lietz, N. G. (2012). In the hot finance jobs, women are still shut out.


## Appendix

Table 5: Calculated Parameters after Estimation

<table>
<thead>
<tr>
<th>Model</th>
<th>IWHR (2)</th>
<th>IWHR (4)</th>
<th>R2D:4D (2)</th>
<th>R2D:4D (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>α</td>
<td>γ</td>
<td>δ</td>
<td>α</td>
</tr>
<tr>
<td>Female</td>
<td>0.4803</td>
<td>0.5581</td>
<td>1.3939</td>
<td>0.4755</td>
</tr>
<tr>
<td>Male</td>
<td>0.3454</td>
<td>0.4867</td>
<td>1.7100</td>
<td>0.3793</td>
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<tr>
<td>Female &amp; High Ratio</td>
<td>0.4541</td>
<td>0.5208</td>
<td>1.3676</td>
<td>0.4545</td>
</tr>
<tr>
<td>Female &amp; Low Ratio</td>
<td>0.5065</td>
<td>0.5954</td>
<td>1.4202</td>
<td>0.4965</td>
</tr>
<tr>
<td>Male &amp; High Ratio</td>
<td>0.2039</td>
<td>0.5331</td>
<td>0.8093</td>
<td>0.1947</td>
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<tr>
<td>Male &amp; Low Ratio</td>
<td>0.4869</td>
<td>0.4403</td>
<td>0.9971</td>
<td>0.5639</td>
</tr>
<tr>
<td>Female &amp; 8s</td>
<td>0.2970</td>
<td>0.4742</td>
<td>0.5412</td>
<td>0.3081</td>
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<tr>
<td>Female &amp; 4s</td>
<td>0.4355</td>
<td>0.5381</td>
<td>0.6872</td>
<td>0.4517</td>
</tr>
<tr>
<td>Male &amp; 8s</td>
<td>0.1793</td>
<td>0.3595</td>
<td>0.5656</td>
<td>0.1977</td>
</tr>
<tr>
<td>Male &amp; 4s</td>
<td>0.3075</td>
<td>0.5182</td>
<td>0.6844</td>
<td>0.3637</td>
</tr>
<tr>
<td>Female &amp; 8s &amp; High Ratio</td>
<td>0.3545</td>
<td>0.4046</td>
<td>0.6123</td>
<td>0.3514</td>
</tr>
<tr>
<td>Female &amp; 8s &amp; Low Ratio</td>
<td>0.2395</td>
<td>0.5438</td>
<td>1.0982</td>
<td>0.2648</td>
</tr>
<tr>
<td>Male &amp; 8s &amp; High Ratio</td>
<td>-0.0360</td>
<td>0.3068</td>
<td>0.4745</td>
<td>-0.2104</td>
</tr>
<tr>
<td>Male &amp; 8s &amp; Low Ratio</td>
<td>0.3946</td>
<td>0.4122</td>
<td>0.6567</td>
<td>0.6058</td>
</tr>
<tr>
<td>Female &amp; 4s &amp; High Ratio</td>
<td>0.5173</td>
<td>0.4928</td>
<td>0.8054</td>
<td>0.4755</td>
</tr>
<tr>
<td>Female &amp; 4s &amp; Low Ratio</td>
<td>0.4882</td>
<td>0.5834</td>
<td>0.5690</td>
<td>0.4152</td>
</tr>
<tr>
<td>Male &amp; 4s &amp; High Ratio</td>
<td>0.1117</td>
<td>0.6135</td>
<td>0.6147</td>
<td>0.0674</td>
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<tr>
<td>Male &amp; 4s &amp; Low Ratio</td>
<td>0.5033</td>
<td>0.4229</td>
<td>0.7541</td>
<td>0.0600</td>
</tr>
</tbody>
</table>
Graphs of Summary Statistics

fWHR on Expected Return and Variance of the Chosen Lotteries

Expected Returns of Chosen Lotteries (Female)

\[ p = 0.656 \]

Expected Returns of Chosen Lotteries (Male)

\[ p = 0.036 \]

Variance of Chosen Lotteries (Female)

\[ p = 0.0494 \]

Variance of Chosen Lotteries (Male)

\[ p < 0.001 \]

Figure 8: Face Ratio on Expected Returns and Variance
R2D:4D on Expected Return and Variance of the Chosen Lotteries

Expected Returns of Chosen Lotteries (Female)  
\[ p = 0.600 \]

Expected Returns of Chosen Lotteries (Male)  
\[ p = 0.561 \]

Variance of Chosen Lotteries (Female)  
\[ p = 0.527 \]

Variance of Chosen Lotteries (Male)  
\[ p < 0.001 \]

Figure 9: Digit Ratio on Expected Returns and Variance
Graphs on Face Ratio:

Utilities of fWHR

Figure 10: Utilities of Face Width-to-Height Ratio (fWHR)
Utilities of fWHR under Time Pressure

Figure 11: Utilities of Face Width-to-Height Ratio (fWHR) under Time Pressure
Figure 12: Rank-Dependent Utilities of Face Width-to-Height Ratio (fWHR)
Figure 13: Rank-Dependent Utilities of Face Width-to-Height Ratio (fWHR) under Time Pressure
Figure 14: Probability Weighting Functions of Face Width-to-Height Ratio (fWHR)
Figure 15: Probability Weighting Functions of Face Width-to-Height Ratio (fWHR) under Time Pressure
Graphs on Reversed 2D:4D Ratio

Utilities of Reversed 2D:4D Ratio

Figure 16: Utilities of Reversed 2D:4D Ratio
Utilities of Reversed 2D:4D Ratio under Time Pressure

Figure 17: Utilities of Reversed 2D:4D Ratio under Time Pressure
Figure 18: Rank-Dependent Utilities of Reversed 2D:4D Ratio
RD Utilities of Reversed 2D:4D under Time Pressure

Figure 19: Rank-Dependent Utilities of Reversed 2D:4D Ratio under Time Pressure
Figure 20: Probability Weighting Functions of Reversed 2D:4D Ratio
PW Functions of Reversed 2D:4D under Time Pressure

Figure 21: Probability Weighting Functions of Reversed 2D:4D Ratio under Time Pressure